SECOND SEMESTER DIPLOMA EXAMINATION IN ENGINEERING
AND TECHNOLOGY
(Common to AR / AU / CE / ME / MT / TD / WP)

ENGINEERING MECHANICS

MODEL QUESTION PAPER

Time: 3 hours Maximum Marks: 75

PART A

I. Answer all questions in one word or one sentence. Each question carries one mark.

(9 x 1 = 9 Marks)

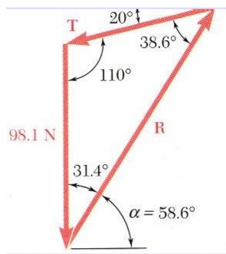
1	An infinite straight line along which the force acts is called ……………….	MO1.01	R
2	A force of 10 kN is acting at 60 with vertical. Determine the horizontal and vertical component of force.	MO1.03	U
3	Define cantilever beam	MO2.01	R
4	No. of restraints in fixed beam is…………	MO2.01	U
5	The position centroid of a triangular lamina from the base is …….	MO3.01	R
6	Name the moment of inertia about an axis(Izz) which is perpendicular to other the mutually perpendicular axes Ixx and Iyy.	MO3.05	U
7	Internal resistance offered by a body against external loading is called……………	MO4.01	R
8	Ratio of lateral strain to linear strain is………..	MO4.05	R
9	The maximum value of static friction comes into play when a body just starts to slide over another is …………..	MO4.06	R

PART B

II. Answer any eight questions from the following. Each question carries 3 marks

(8 x 3 = 24 Marks)

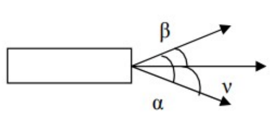
1	Differentiate scalar quantity and vector quantity	MO 1.02	R

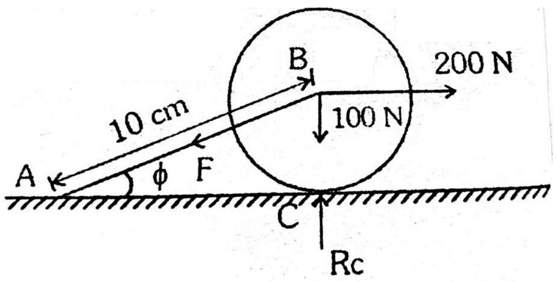
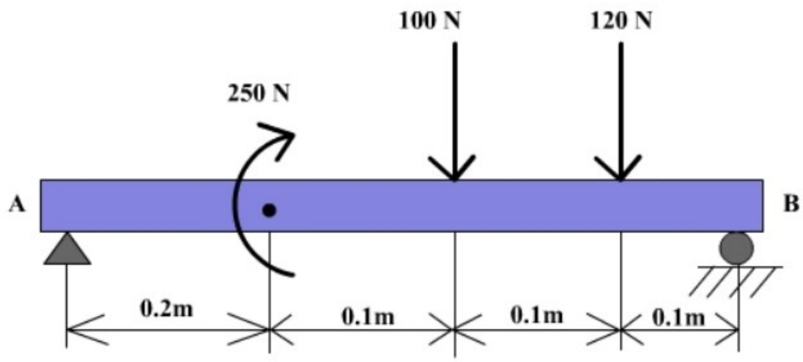
2	Determine the magnitude of the reaction force R 	MO1.03	U
3	State Varignons theorem	MO1.03	R
4	Define simply supported and cantilever beam.	MO2.01	R
5	Sate the laws of friction	MO2.05	R
6	Illustrate the center of gravity of the following solid bodies a) Hemisphere b) Cone	MO3.01	R
7	State perpendicular axis theorem	MO3.04	R
8	Draw the stress strain curve of steel and explain the terms a) Limit of proportionality b) Ultimate stress	MO4.02	R
9	Explain the following properties a) Elasticity b) Plasticity c) Toughness	MO4.04	R
10	The value of modulus of elasticity and poisons ratio of an alloy body is 150GPA and 0.25 respectively. Determine the value of bulk modulus of the alloy.	MO4.05	U

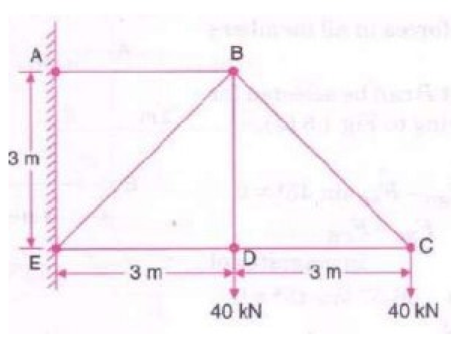
PART C

Answer all questions. Each question carries seven marks

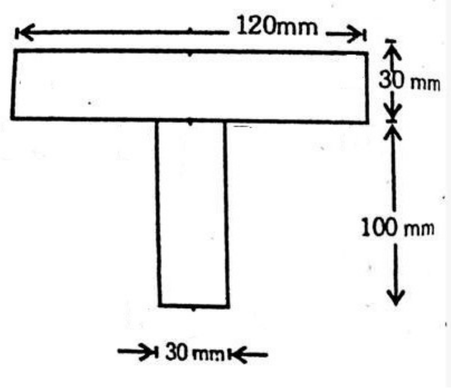
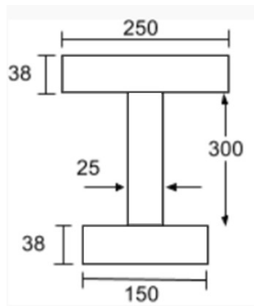
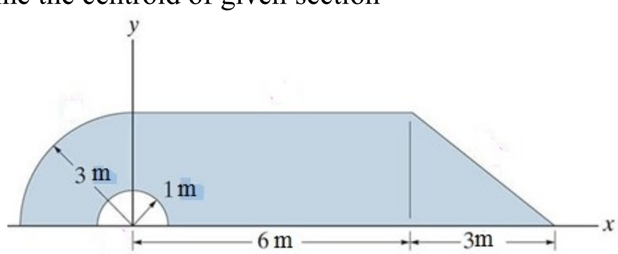
(6 x 7 = 42 Marks)

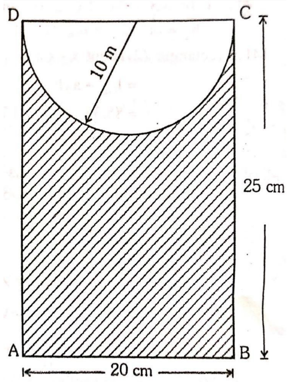
III	A boat is moved uniformly along a canal by two horses pulling with forces P = 890 N and Q = 1068 N acting under an angle α = 60˚. Determine the magnitude of the resultant pull on the boat and the angles β and ν.  **OR**	MO1.03	A

<table>
<tr><td>IV</td><td>A circular roller of radius 5 cm and weight of hundred 100N rest on a smooth horizontal surface and is held in position by an inclined bar AB of length 10 cm as shown in figure. A horizontal force 200 N is acting at B. Find the force in the bar a B and a vertical reaction at C.

</td><td>MO1.03</td><td>A</td></tr>
<tr><td>V</td><td>Find the reactions at the supports for a simple beam as shown in the diagram. Weight of the beam is negligible.


OR</td><td>MO2.02</td><td>A</td></tr>
<tr><td>VI</td><td>Define friction. Explain the different types of friction</td><td>MO2.05</td><td>R</td></tr>
<tr><td>VII</td><td>Compute the forces in members of the given truss.


OR</td><td>MO2.03</td><td>A</td></tr>
<tr><td>VIII</td><td>A pull of 20N inclined at 25 ° to the horizontal plane is required just to move a body placed on a rough horizontal plane. But the push required to move the body is 25 kN. If the push is inclined to</td><td>MO2.05</td><td>U</td></tr>
</table>

	25 ° to the horizontal, find the weight of the body and coefficient of friction.		
IX	Locate the centroid of the given figure.  **OR**	MO3.02	U
X	Determine the moment of inertia about the centroidal axes of given I section beam given below. All dimensions in mm  	MO3.04	U
XI	Determine the centroid of given section  **OR**	MO3.02	U
XII	Find out the moment of inertia of the shaded area in the figure about the base.	MO3.04	A

			
XIII	A rod 150cm long and of diameter 2.0cm is subjected to an axial pull of 20kN. If the modulus of elasticity of the material of the rod is 2×10^5N/mm^2, determine : (i) the stress (ii) the strain and (iii) the elongation of the rod **OR**	MO4.01 MO4.03	U
XIV	Determine the changes in length, breadth and thickness of a steel bar which is 4m long, 30mm wide and 20mm thick and is subjected to an axial pull of 30kN in the direction of its length. Take E=2×10^5 N/mm^2 and Poisson's ratio = 0.3	MO4.03 MO4.05	A

ANSWER KEY

ENGINEERING MECHANICS

MODEL QUESTION PAPER

PART A

Answer all the following questions **(9 x 1 = 9 Marks)**

I

Q.No	Answer	Split up	Total Mark
1	Line of action of force	1	1
2	Vertical component = 10 Sin60 Horizontal component = 10 Cos60	1	1
3	A beam with one end fixed and other end free	1	1
4	3	1	1
5	h/3	1	1
6	Polar moment of inertia	1	1
7	Stress	1	1
8	Poisons ratio	1	1
9	Limiting friction	1	1

II. **PART B**

Q.No	Answer	Split up	Total Mark
1	Scalars: only magnitude is associated. Ex: time, volume, density, speed, energy, mass Vectors: possess direction as well as magnitude, and must obey the parallelogram law of addition (and the triangle law). Ex: displacement, velocity, acceleration, force, moment, momentum	1 1 1 1	3

2	$$\frac{T}{\sin 31.4} = \frac{R}{\sin 110} = \frac{98.1\text{N}}{\sin 38.6^{\circ}}$$ $$T = 81.9\text{N}$$ $$R = 147.8\text{N}$$	2 1	3
3	The moment of the resultant of two concurrent forces with respect to a center in their plane is equal to the algebraic sum of the moments of the components with respect to some centre.	3	3
4	simply supported beam is supported at both ends. One end of the beam is supported by hinge support and the other one by roller support. Cantilever beam is a structural member of which one end is fixed and other end is free	1.5 1.5	3
5	1. Friction always acts in the direction opposite to the motion or impending motion. 2. The limiting friction is directly proportional to the normal reaction. 3. Until the motion starts the static frictional force adjust itself to just balance the force tending to produce motion. 4. Friction is independent of the area of contact between the two surfaces but depends on the roughness of the surface. 5. Kinetic friction also bears a constant ratio with normal reaction but this ratio is slightly less than that in the case of limiting friction. 6. For moderate speeds, friction remains constant but it decreases slightly for higher speeds.		3
6	a)	1.5	

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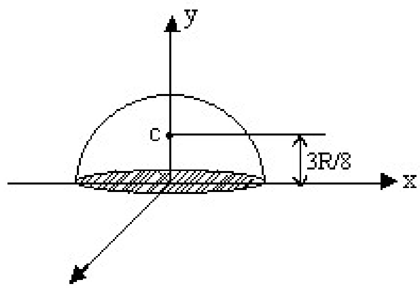
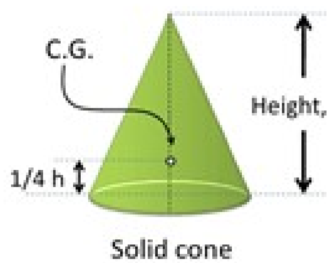
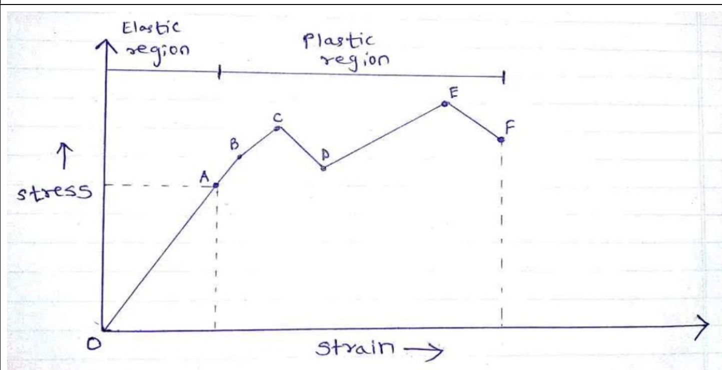
<tr><td></td><td>

b)


</td><td>1.5</td><td>3</td></tr>
<tr><td>7</td><td>The theorem states that the moment of inertia of a plane lamina about any two mutually perpendicular axes in its plane and intersecting each other at the point where the perpendicular axis passes through it.
$I_{zz} = I_{yy} + I_{xx}$</td><td>3</td><td>3</td></tr>
<tr><td>8</td><td>

Stress Strain Curve For Mild Steel

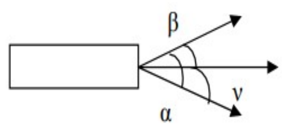
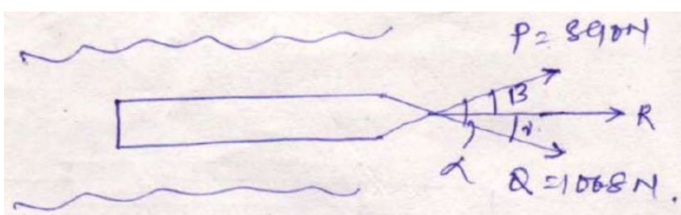
a)Limit of proportionality

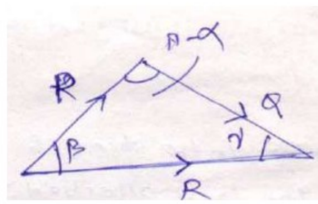
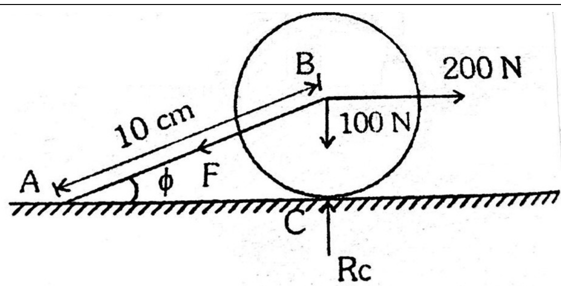
Point A, in this limit the stress is directly proportional to strain { $\sigma \propto e$ }, that means the steel rod obeys ‘Hooke’s law

b)Ultimate stress</td><td>1</td><td></td></tr>
</table>

	Point is 'E' which is called as ultimate stress or ultimate strength point. Ultimate stress is the maximum stress the rod can with stand, thus this portion is called a strain hardening.		
9	a) Elasticity: The ability of an object or material to resume or regain its normal shape or original shape after being stretched or compressed called Elasticity. b) Plasticity: he quality of being easily shaped or molded called Plasticity. c) Toughness: t is the state of being strong enough in order to withstand adverse conditions or rough handling called Toughness	1 1 1	3
10	$K=E/3(1-2/m)= (150\times10^3)/3(1-2\times0.25)=100GPa$	1+1+1	3

PART C

III	$P = 890$ N, $\alpha = 60^\circ$ $Q = 1068$ N $R=\sqrt{(P^2+Q^2+2PQ\cos\alpha)}$ $=\sqrt{(890^2+1068^2+2\times890\times1068\times0.5)}$ $= 1698.01N$  	2 1 2	7

	$\frac{Q}{\sin\beta}=\frac{P}{\sin\nu}=\frac{R}{\sin(\pi-\alpha)}$ $\sin\beta=\frac{Q\sin\alpha}{R}$ $=\frac{1068\times\sin60^\circ}{1698.01}$ $=33^\circ$ $\sin\nu=\frac{P\sin\alpha}{R}$ $=\frac{890\times\sin60^\circ}{1698.01}$ $=27^\circ$ 	2	
	OR		
IV	 In triangle ABC Sinφ =5/10=0.5 $\Phi=30^\circ$ Consider roller in equilibrium and apply condition of equilibrium ΣH=0 and ΣV=0 Resolving forces horizontally FCos30-200 =0 Force in bar AB , F=200/Cos30=230.9N Resolving forces vertically Rc -FSin30-100=0 Rc = 230.9Sin30+100=215.47N	1 2 1 2	

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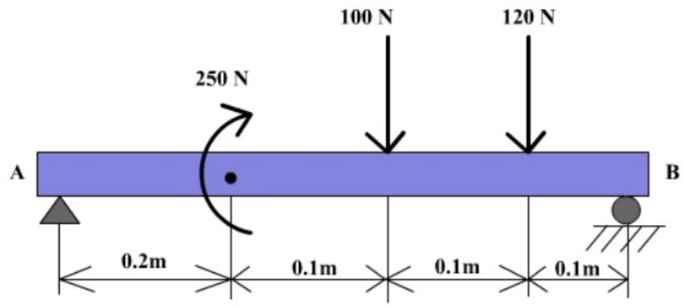
<tr><td>V</td><td>

Apply equilibrium equations
In X direction $\sum FX = 0 \Rightarrow R_A = 0$
In Y Direction $\sum FY = 0$
$\Rightarrow R_A+R_B - 100 - 160 = 0 \Rightarrow R_A+R_B = 260$
Moment about Z axis (Taking moment about axis pasing through A)
$\sum MZ = 0$
We get, $\sum MA = 0$
$0 + 250 + (100 \times 0.3) + 1200 \times 4 - R_B \times 0.5 = 0$
R_B= 656 N (Upward)
$\sum MB = 0$
$(R_A \times 0.5) + 250 - (100 \times 0.2) - (120 \times 0.1) = 0$
R_A = -436 (downwards)</td><td>2
2
1
2</td><td>7</td></tr>
<tr><td>VI</td><td>Friction is defined as the force that opposes the motion of a solid object over another. There are mainly four types of friction: static friction, sliding friction, rolling friction, and fluid friction.
<u>Static Friction</u>
Static friction is defined as the frictional force that acts between the surfaces when they are at rest with respect to each other.
The magnitude of the static force is equal in the opposite direction when a small amount of force is applied. When the force increases, at some point maximum static friction is reached.
Static Friction Examples
Following are the examples of static friction:</td><td>2
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1</td><td></td></tr>
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	• Skiing against the snow • Creating heat by rubbing both the hands together • Table lamp resting on the table <u>Sliding Friction</u> Sliding friction is defined as the resistance that is created between any two objects when they are sliding against each other.	1	
	<u>Examples Of Sliding Friction</u> Following are the examples of sliding friction: • Sliding of the block across the floor • Two cards sliding against each other in a deck <u>Rolling Friction</u> Rolling friction is defined as the force which resists the motion of a ball or wheel and is the weakest types of friction.	1	
	Examples Of Rolling Friction Following are the examples of rolling friction: • Rolling of the log on the ground • Wheels of the moving vehicles <u>Fluid Friction</u> Fluid friction is defined as the friction that exists between the layers of the fluid when they are moving relative to each other.	1	
	Examples Of Fluid Friction Following are the examples of fluid friction: • The flow of ink in pens • Swimming		7

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<td>VII</td>
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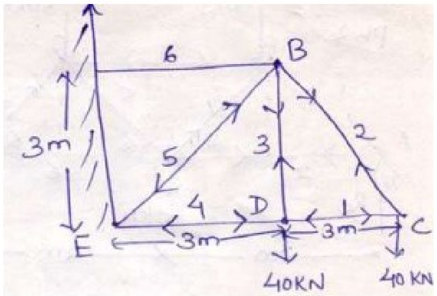
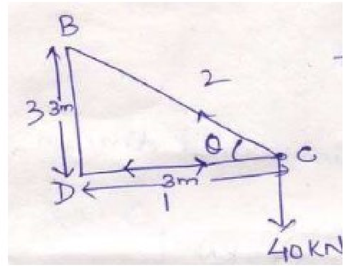
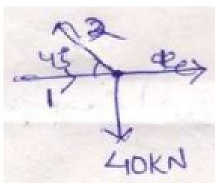
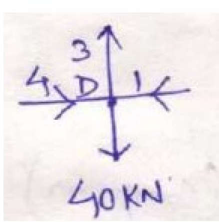




tanθ = 1, θ = 1
<u>JOINT C</u>


$S_1 = S_2 \text{ Cos } 45$
= 40kN (Compression)
$S_2 \text{Sin } 45 = 40$
S_2 = 56.56kN (Tension)

<u>JOINT D</u>


S_3 = 40 kN (Tension)
$S_1 = S_4$ = 40 kN (Compression)

<u>JOINT B</u>
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<td>1
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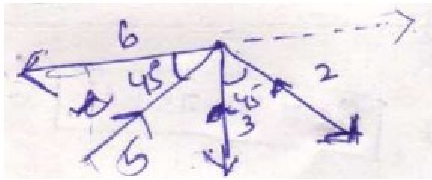
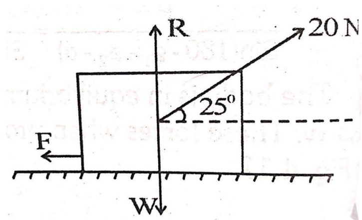
	 Resolving vertically, $\Sigma V = 0$ $S_5 \sin 45 = S_2 \sin 45$, $S_5 = 113.137$ kN (Compression) Resolving Horizontally, $\Sigma H = 0$ $S_6 = S_5 \cos 45 + S_2 \cos 45$ $S_6 = 113.137 \cos 45 + 56.56 \cos 45$ $= 120$ KN	1 1 1	1 1
VIII	 Pull required, P= 20 N Inclination of pull, $\Phi = 25°$ Push required $P_1 = 25$ N Inclination of push, $\Phi = 25°$ Resolving forces along the plane $F = 20 \cos 25°$ Resolving forces normal to plane $R + 20 \sin 25 = W$	1	

R= W-20 Sin 25 = W

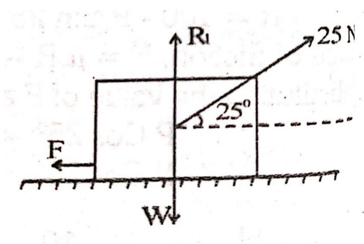
R = W- 8.452

Force of friction F = μ R 1

20 cos 25 = μ(W-8.452)

μ (W-8.452) = 18.126…………………………..(1)

When the body is pushed the body is in equilibrium under the action of forces given below



Resolving the forces along the plane

$F=\mu R_1$ = 25Cos 25 = 22.657

1

Resolving forces normal to plane

R_1 = W+ 25 Sin 25 = W+10.565

μ (W+10.565) = 22.657………………………………(2)

Dividing equation (1) by (2) 1

22.657(W-8.452) = 18.126(W-10.565)

W = 383/4.53 = 84.547

Substituting value of W in (1) 1

μ= 18.126/76.095 = 0.238

2

7

IX

Figure	Area mm^2	y mm	Ay
1	120x30=3600	(30/2)+100=115	36000X115= 414000

2

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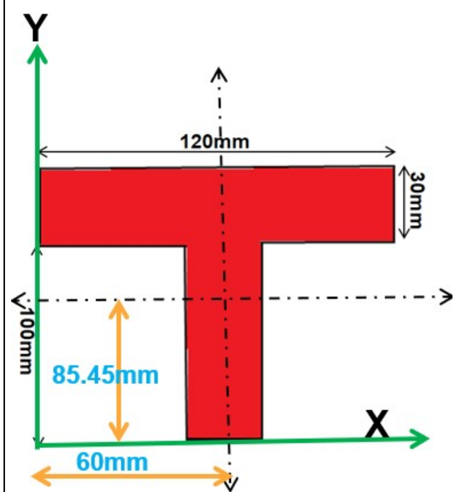
<table>
<tr><td>2</td><td>30x100=3000</td><td>100/2=50</td><td>3000x50=
150000</td></tr>
<tr><td></td><td>∑A=6600</td><td></td><td>∑Ay=564000</td></tr>
<tr><td colspan="4">$\bar{y}$ $=\sum Ay_i/A$
$= 564000/6600$
$=85.45mm$ $\bar{x}$ $=60mm$</td></tr>
</table>


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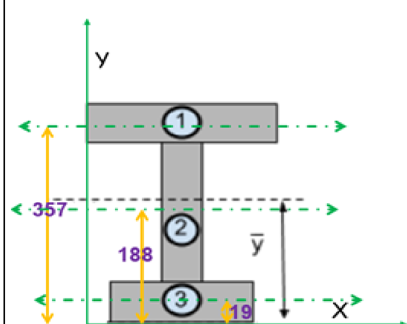
X

Fig.	Area mm^2	IG_X=	IG_y=	$\bar{h}$ mm	$A\bar{h}2$
1	9500	$250x38^3/12$ $=1.14x10^6$	$38x250^3/12$ $=4.95x10^7$	140.7	$9500x140.7^2$
2	7500	$25x300^3/12$ $=5.62x10^7$	$300x25^3/12$ $=3.9x10^5$	28.3	$7500x28.3^2$
3	5700	$150x38^3/12=6.85x10^5$	$38x150^3/12$ $=1.07x10^7$	197.3	$5700x197.3^2$
	$\sum A$= 22700	$\sum IG_x$ $=5.8x10^7$	$\sum IG_y$ $=6.06x10^7$		$\sum A\bar{h}2$= $4.15x10^8$



$\overline{h1} - (38 + 300 + 38)$ –(38/2)-216.3

=140.7mm

$\overline{h2} = 216.3 - (38 + \frac{300}{2})$

=28.3mm

$\overline{h3} = 216.3 - (38/2)$

=197.3mm

2

1

Fig.	$\bar{h}$ mm	IG_x mm^4	IG_y mm^4	$A\bar{h}^2$
1	140.7	$250x38^3/12=1.14x10^6$	$38x2503/12=4.95x10^7$	9500x140.72
2	28.3	$25x300^3/12=5.62x10^7$	$300x253/12=3.9x10^5$	7500x28.32
3	197.3	$150x38^3/12=6.85x10^5$	$38x1503/12=1.07x10^7$	5700x197.32
		$\sum IG_x=5.8x10^7$	$\sum IG_y=6.06x10^7$	$\sum A\bar{h}^2=4.15x10^8$

2

1

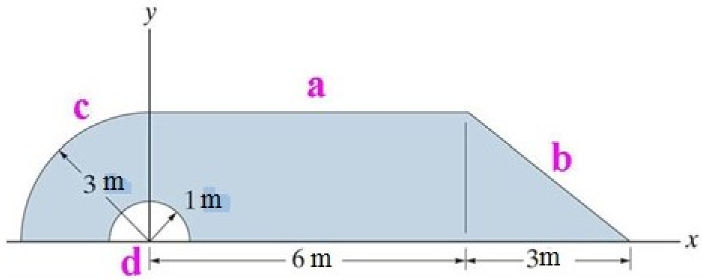
$I_{GX} = 5.8x107 + 4.15x108$

$= 4.73x10^8 mm^4$ 1 7

$I_{GY} = 6.06x107mm4$

$I_{AB} = I_G + A\bar{h}^2$

XI



This body can be divided into the following pieces:

rectangle (a) + triangle (b) + quarter circular (c) – semicircular area (d). (Note the negative sign on the hole!)

Area	A (m^2)	$\tilde{x}$(m)	$\tilde{y}$ (m)	$\tilde{x}A$(m^3)	$\tilde{y}A$ (m^3)
a	18	3	1.5	54	27
b	4.5	7	1	31.5	4.5
c	$9\pi/4$	$-4\times 3/3\pi$	$4\times 3/3\pi$	-9	9
d	$-\pi/2$	0	$-4\times 1/3\pi$	0	-2/3
Σ	28.0			$\Sigma\tilde{x}A$ =76.5	$\Sigma\tilde{y}A$ =39.83

5

$$\bar{x} = \frac{\Sigma\tilde{x}A}{\Sigma A} = \frac{76.5}{28.0} = 2.73\ m$$

1

$$\bar{y} = \frac{\Sigma\tilde{y}A}{\Sigma A} = \frac{39.83}{28.0} = 1.42\ m$$

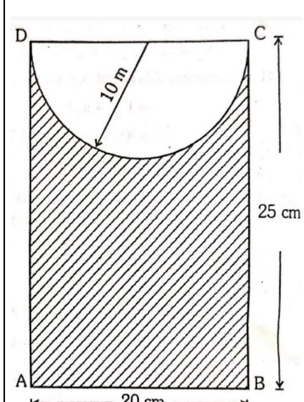
1

XII

Radius of circle =10cm

Width of rectangle=20cm

Depth of rectangle=25cm



	MOI of rectangle ABCD about AB $I_{AB}= I_G+Ah^2$ $= (20\times25^2)/12+(20\times25\times(25/2)^2$ $= 104167cm^4$	1	
	MOI of semicircle about DC $I_{DC} = (\pi d^4/64)/2$ $= (1/2)\times (\pi\times20^4)/64$ $= 3925cm^4$	1	
	$h = 4r/3\pi$ $= (4\times10)/3\pi$ $= 4.24cm$ Area of a semicircle $= \pi r^2/2$ $=\pi\times10^2/2$ $= 157.1\ cm^2$	1	
	MOI of semicircle about a lone through its CG parallel to CD $I_G = I_{DC} -Ah^2$ $= (3925-157.1) \times 4.24^2$ $= 3925-2824.28$ $= 1100.72cm^4$	1	
	Distance of CG of semicircle from AB $= 25-4.24$ $= 20.76cm$	1	
	MOI of semicircle from AB $I_{AB}= I_G+Ah^2$ $= 1100.72+157.1\times 20.76^2$ $= 1100.72+67706.58$ $= 68807.30cm^4$	1	
	MOI of shaded portion about AB $= 104167-68807.30 = 35359.7cm^4$	1	7

XIII	L = 150cm D = 2cm Area = $\pi/4(20)^2 = 100\pi\ cm^2$ P = 20 kN E = 2×10^5 N/mm^2 (i) Stress = P/A = 20000/100π = 63.662N/mm^2 (ii) Strain e = σ/E = 63.662/2×10^5 = 0.000318 (iii) Elongation dL= e × L = 0.000318 × 150 = 0.0477cm	2 2 2	
XIV	L= 4m b = 30mm t = 20mm A = b × t = 30 × 20 = 600 mm^2 P = 30 kN = 30000 N E =2×10^5 N/mm^2 μ = 0.3 Longitudinal strain e = P/AE = 30000/600 ×2×10^5 = 0.00025 e = dL/L = 0.00025 dL = 0.00025 × 4000 = 1.0 mm Poisson's ratio, μ = lateral strain / longitudinal strain lateral strain = 0.3 × 0.00025 = 0.000075 db = b × lateral strain = 30 × 0.0000075 = 0.00225 mm. dt = t × lateral strain = 20 × 0.0000075 = 0.0015 mm.	1 1 1 1 1 1 1	7